INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
Materials Management Division
For IIT GOA

Field Emission Scanning Electron Microscope

Essential Specifications:
The Instrument must be of high resolution with ***Schottky (Thermal) Field Emission*** type electron source. The instrument with latest technology and must have following minimum specifications.

Specifications:

1.	Resolution	1.0 nm or better at 15KV and 1.6 nm or better @1 KV
2.	Magnification	25X or less to 1000000X or higher
3.	Accelerating Voltage	Continuously adjustable from 0.50 to 30 kV or more
4.	Chamber	Large enough to house 5 or more accessory ports.
5.	Stage	Motorized stages with 5 axis movement of X= 100 mm or higher; Y=100 mm or higher; Z=50 mm or higher; Tilt= 0° to 60° or more; R=360° (continuous rotation) Sample holder must have enough size to accommodate 8 or more 1cm^2 samples.
6.	Probe Current	10 nA or less to 100nA or higher
7.	Detectors	In lens SE, BSE, Everhardt-Thornley SED, For in-chamber viewing CCD Camera with IR illumination
8.	User interface	Fully computer controlled system with window based Software to operate the microscope along with keyboard, mouse, and control panel including multifunction for control and adjustment of frequently used SEM parameters. Manual joystick control for motion of stage axis. The easily accessible image data files. Storage of files in external central database computer.
9.	Electron optics	Thermal (Schottky) field emission gun. Advanced technology for high resolution imaging at low KV. The system must demonstrate the capability of imaging both non-conducting & conductive samples with resolution of 0.7nm or better. (i) Beam Deceleration/Beam Booster technology/Gentle Beam technology or equivalent for high

		resolution imaging at low kV. (ii) The system must have Magnetic/Electrostatic objective/Super hybrid lens or equivalent lens assembly for high resolution imaging of magnetic materials especially with shorter working distance.
10.	Working Distance :	1 mm or less to 50 mm or more (preferable)
11.	Display	Two 24" LED Monitors for FESEM. One for control another for Imaging.
12.	Vacuum system	Vacuum system having ion pump/Oil free Pump. Should have pumping Time < 5 minutes after Specimen Exchange.
13.	Essential Accessories	a) Compressor, b) IRCCD camera, c) Chiller. d) Interface between SEM and EDS.
14.	Computer	Most updated Desktop system with Pentium I7 core processor, speed ≥3 G Hz, HDD Memory ≥1 Tb, RAM≥ 8 GB , DVD writer, sufficient USB ports and most updated windows based software, and 24 inch LED monitor.
15.	Software packages	Particle size analysis and image processing software, windows based software, and multiple offline licenses for analysis. The latest version of software for the quoted model should be included. For off-line analysis suitable interfacing, if required, should be provided for another computer for further analysis. Data formats (ACSII, TIFF, JPEG, BMP, etc.) Backup software must be provided on optical media. Any further version of the software and updates must be provided free of cost.
16.	Calibration	Standards for calibration of magnifications, dimensional and resolution.
17.	EDS system	Liquid Nitrogen Free, Peltier cooled high resolution high speed silicon drift detector with ≥ 30 mm^2 detector area with Solid angle ≥ 0.4 Sr. Resolution ≥ 123 eV at MnKα and carbon resolution 50eV in compliance with ISO 15632:2012 specifications. . Detector can process at greater than 1 Mcps input and greater than

		800cps output. The detector should be capable of detecting from Be to U and Quantification from B to U based on ZAF method. The EDS system with software should be capable of single point analysis, multipoint analysis, selective element mapping, line scan, selected area analysis, qualitative and quantitative analysis (with ZAF correction) and real time phase mapping. Supplied EDS server & analysis software should be capable of performing data acquisition, storing and transfer in common Windows based application format. It should have features like peak auto identification routine, spectral match analysis, automatic background subtraction, spectrum process using filters, least square fitting and peak de-convolution. Pile up correction and and back ground noise reduction, simultaneous imaging and analysis should be possible All these capabilities should be applicable for polished flat specimens, fractured samples and nanostructured particulate systems. Backup software must be provided in optical media. Any further version of the software and updates must be provided free of cost. The supplier should arrange for seamless interfacing, software, installation and commission for EDS system. Training for the user shall be arranged for 4 working days for 3 persons. **Calibration standard (Preferably from NIST)** – 1 No's with 36 element standard materials suitable for use with EDS systems. The materials should be mounted on a 1" or 1.25" diameter stub with a Faraday cup for Beam Current measurements. The elements are those commonly required for metals, alloys, nitrides, oxides etc. Complete set of user manuals should be provided for the EDS system. System should be integrated with EBSD and SEM systems.
18.	EBSD (Optional)	• The EBSD system should work on the same computer

		platform as that of EDS system. • The EBSD camera system should be highly sensitive one to cater to Nano-area analysis application. • The EBSD camera should be using minimum 12 bit digital CCD with on-chip integration. • Fast camera with at least 150 fps or more speed. • The EBSD camera should have rectangular/circular phosphor exactly matched to CCD chip size. The phosphor should be optimized for low –kV data application while working with SEM. • The EBSD camera should have motorized insertion and retraction mechanism with remote control digital handset. The position accuracy is to be 0.1mm. • The camera movement should have audible safety alarm with auto retract mechanism. • The EBSD camera should have tapered nose design to allow EDS detector to come very close to sample at shorter working distances. • Calibration standard as required. • The camera interface to SEM should have sliding and tilting interface plate to correctly position the camera at the shortest possible EBSD for optimal special resolution. **The system software should include following features: -** • Data acquisition software with accessible data file. • Phase reflector file creation software • Pole figure software • Mapping software • ODF software • Imaging and beam control software • Stage control software • Phase identification software Backup software must be provided in optical media. Any further version of the software must be provided free of cost. Complete set of user manuals should be provided for the EBSD system.

19.	STEM (Optional)	This module should contain the hardware and system software modules as below: - The scan driver electronics for the AC beam coils - Video selection and mixing card; - Advanced STEM imaging capabilities including state of the art CMOS camera, driver and software - Amplifiers and filters; - The ether link for controlling the STEM System hardware. - Software device drivers and software control elements for the scan amplitudes to change STEM magnification and rotation and software device drivers and software control elements for amplifiers, filters, video selection and video mixing. **Detectors:** The On-axis Bright-field/Dark-field STEM detector: should be composed of a bright field detector and two dark-field detectors. All detectors should be silicon solid-state detectors, and support a beam current up to 3 nA. The On-axis BF/DF detector is particularly useful for Z-contrast imaging and EELS. Furthermore, the design of the On-axis BF/DF detector should allow for simultaneous acquisition of the signal of (a) the bright-field detector and (b) one of the dark-field detectors. This on-axis BF/DF detector should be compatible with below the chamber cameras and with EELS (PEELS and GIF). This should include the required pre-amplifier as well as the pneumatic controls for all three detectors. The module also should contain the necessary device driver software. HAADF Detector: The High-Angle, Annular Dark Field detector (HAADF) is used in TEM/STEM systems to generate (atomic resolution) dark-field STEM images. Construction: the detector should be retracted pneumatically, with the possibility of mechanical alignment to center it around the electron beam. The quartz tube should link the YAP to the PMT, which should be mounted directly onto this tube. The re- positioning accuracy after retraction and reinsertion should be < 0.1 mm. Supporting electronics, preamp and preamp control boards should be included. The module should also contain the device driver software and control

		elements for the preamp control board. **External Scan Switch Facility**: External Scan Switch Facility for allowing the scanning coils to be driven by an external line and frame generator. This module should provide the capability of switching between the standard scan signals which are normally produced by the TIA scan generator in the TEM workstation and an external scan signal produced by another source like EDS or EELS spectrometer
20.	E-Beam Lithography (Optional)	1. The system must include the beam spot size: 3-5 nm or better at 20-30 kV. 2. Minimum feature size:16-20 nm or better. 3. Selectable operating voltage range: 0.1 - 30 kV. 4. Beam energy: 100 eV to 50 keV or better as per resolution. 5. Probe current: 5 pA to 20 nA or better as per resolution. 6. Beam current stability: 0.5% in 1 hour for ambient temperature variation ±0.5 °C. 7. Beam position drift: Less than 300 nm/hour. 8. Automatic drift correction during scanning. 9. Writing speed 10MHz. 10. Field stitching 100 nm (mean + 2 sigma) 11. Beam deflection system capable for writing field size from submicron to 1mm or above and returning to same location after one horizontal scan. 12. Maximum pattern area: 50 mm x 50 mm with writing capability on a smaller substrate 25 mm travel range in Z axis with automated height sensing. 13.The system must include the fast electrostatic beam blanker with motorized retractable blanking plate and adjustable polarity. 14. Universal holder for smaller substrate Closed loop XY stage position control with DC motor/Piezo drive XY stage positioning resolution: 2nm 16 bit multiple DAC for pattern control. 15. The system must include the lithography capability: Single isolated structure, Mix & match with local mark recognition functionality. 16. The system must have the exposure module: Vector scan mode exposure of all types of arbitrarily shaped areas and

		curves, single pixel lines and dots, bitmaps in raster scan mode. 17. Provision for charge neutralizer fully automatic low maintenance oil free vacuum system with turbo molecular pump backed by dry pump and other necessary accessories to achieve chamber vacuum better than 5x10-6 mbar System control software and Proximity error correction software (It may be included in the FESEM, but it must be compatible with E Beam lithography). 18.Multiuser Environment with separate files and parameters for each users and acceptable data format: GDSII, DXF, ASCII, CIF Advanced exposure software for multidirectional patterning mode Additional software license for offline PC data preparation Inspection and dimensional metrology software. 19. Software must be a sole package for all modes and attachments with no need for additional software programs. 20. Software package must include both image acquisition and data processing software in one package with no need for different programs operation. 21. Software must be free-for copy, e.g., can be installed on unlimited number of off line PC. 22. Scanning-electron-based sample imaging, metrology and inspection capable up to minimum feature size for 3 nm -20 nm or better. 23. Detector for shadow- and distortion-free images at low voltages Image. • Detailed Instruction Manuals must be supplied with the instruments. • Fast fiber optic control interface preferable. Backup software must be provided in optical media. Any further version of the software and updates must be provided free of cost. **<u>Accessories</u>** EBL start kit consisting of diamond cutter, tweezers, sample, coated with PMMA resist and all required tools. Sample holder for wafer pieces with tin ball sample, sample holding

		spring and faraday cup. Calibration sample (Chessy patterns or similar).
21.	Micromanipulator for electrical & mechanical measurements inside FESEM (optional)	Four -Three-axes micromanipulator system for Electron Microscopy. Should travel in the linear axis 12 mm, travel in the rotational axes 240°. The system should include control electronics, joy pad, iprobe control software, tip holders for probe tips with required accessories and vacuum feed through. The system should also have Low Current Measurement Kit to measure low current, low capacity measurement on conductive/semiconductive samples upto 10fA. The kit should consist of probe tip holder, all triax cables, feed through and vacuum flange. The system should include control device with Advance probing technique-Live contact tester for safe approach of tips to the specimen. The system should be complete in all respect for measuring Four Point Probe measurements. Should have a micro gripper for handling samples for Force measurements, for nanoindentation and tensile measurements with force measurement tool for up to 8Nor more. All required software for measurements should be included. Following consumables should be included in the offer: (i) Force sensors of length 120µm, tip radius < 20 nm, tip height > 5 µm, tip force constant nearly 30 to 40 N/m andf force resolution 10 nN – 10 Nos (ii) flat Sample Stubs for the Prober Shuttle – 50 Nos (iii) Glass Pipettes – 10 nos (iv) Probe Tips (tip radius 500 nm, solid W needle)- 25 Nos The offer should include installation & training by industry trained engineers for three days after installation. Two similar trainings afterwards and when required by IIT Goa.
22.	Heating Module (optional)	500° C or more heating module for sample heating with PID controller. The module should be properly insulated and should not damage the system in routine use.
23.	Ion sputter coater	Ion sputter coater with Pt/Pd 80/20 alloy as default material with rotary vacuum pump (without any gas supply). Performs thin-film (<10 nm). Planetary rotate and tilt stage for high-topography samples.

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Quote optional accessories separately.

Installation requisites:
All the prerequisites for installation have to be quoted. Institute will only provide electricity at 220V, 50Hz, normal quality water and space.

Safety devices:
Suitable online 10 KVA UPS systems to run the system safely at least for two hrs.

Warranty and maintenance:

1. The complete comprehensive onsite warranty for 5 years (excluding breakdown periods) for the entire system, including the filaments etc.
2. In case of breakdown during the warranty period, a competent service engineer of the supplier should make as many visits as are necessary to rectify the problem and replace the faulty parts, without any liability of cost. But it should be repaired within 72 working hours from the date and time of complaint lodged by the user. In case of any delay in repair without adequate justification, there will be penalty of rupees 5,000/- per day for the down time. Supplier should ensure to provide all spares required for making the instrument operational. The spares recommended for keeping in inventory along with the instrument may also be quoted.

Annual maintenance contract:
After warranty, AMC (year wise) charges should also be quoted as optional.

Installation and training
Installation should be done by the manufacturer. On-site one week training for operation and application may be given to the users free of cost. IIT Goa will not bear any training or leaving expenditure in this regard.

Spare parts
The supplier of the instrument must confirm in writing that the spares for the entire instrument will be available for a period of at least ten years after the model of equipment supplied has been phased out. For frequently required spares, there should be adequate inventory with the Indian agency.

Manual
One set of operating manual and service manual including detailed drawings and circuit diagrams (in English) should be provided with the instrument

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User list with contacts
Vendor should provide us a list of installations in India with all contact details and model details so that IIT Goa can approach the contact person for any feedback. In case of any doubt about capability of the machine, the vendor will have to arrange demonstration at any site bearing the cost including the travel and other expanses of IIT Goa representatives.

Compliance statement
The supplier must submit technical brochures and proper application notes adequately explaining and confirming the availability of the features in the model of the equipment being quoted.

The supplier must submit a table indicating the compliance of the features of the model of the equipment being quoted with those given in the indent. Features not matching – must be clearly indicated.

Additional features and Features in the quoted equipment which are better than those in the indent – may be clearly explained.

The vendor may certify that the equipment and accessories quoted provide a complete package for use of SEM along with analysis by EDS, EBSD and e-beam lithography.

Merely complying all above specifications does not imply that system is technically acceptable. Qualifying technically is subjected to successful demonstration of its imaging capabilities in presence of a technically competent person from IIT Goa. Bidder should bear the cost of demonstration of equipment capabilities.

Other Requirements:

1. Demonstration of all the functionalities of FESEM imaging process, showing specified resolution on standard samples such as Gold and Tin ball, and testing on various user's sample must be done at the time of installation. All standard specimens should be provided by the vendor.
2. The vendor should have at least 10 FESEM installations across the country in last 10 years. The Committee may relax the number of installation required.
3. Lifelong upgradation of all software for imaging, analysis & EDS etc should be included.
4. List of spares that can be kept in stock should be provided with price.